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This study explored whether microscopic magnetic resonance imaging (MRI) could help to determine the nature of suspicious breast lesions. After mammography identifies a suspicious lesion, there is currently no reliable, noninvasive way to determine whether the lesion is malignant, which results in unnecessary biopsies. In this study, we developed a special set-up, to be used in a GE Signa 1.5T magnet. The breast was gently compressed and small receiver coils were used to detect the MR signal to produce very high resolution images of the breast lesions. Using these coils, as well as a contrast agent, several types of images were obtained for all patients. There were 6 patients, all of whom underwent biopsies, and the biopsy results were compared with the acquired images.

The resolution was sufficient to be able to characterize the structure of the lesions. The most significant difference between the two types of lesions was the border appearance of each lesion. Benign lesions had smooth edges and malignant lesions had infiltrating edges. Very high resolution MRI could help to diagnose suspicious lesions and reduce the number of unnecessary biopsies.

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Chris A. Parker 7/2/97

PI - Signature Date

TABLE OF CONTENTS

INTRODUCTION

In our original submission, we proposed to develop and test an apparatus and a method for localized high spatial and temporal resolution MR imaging of breast lesions applicable to humans. Our apparatus would also permit the guidance of biopsy needles to selected lesion(s). The rationale behind our proposal was that current observed trends in the clinical management of breast cancer indicate that existing imaging methods do not provide sufficient information to improve the detection, diagnosis, and management of breast cancer. After mammography identifies a suspicious lesion, there is currently no reliable, noninvasive way to determine whether the lesion is malignant, which results in unnecessary biopsies.

The evaluation of undisturbed lesion architecture, an important histological criterion for lesion characterization, is impossible with minimally invasive needle biopsy techniques. The level of resolution of our technique was designed to increase the specificity of imaging assessment by providing unique histological characteristics, including ductal morphology and lesion/duct relationships, microcalcification assessment (using T2* sensitive sequences), and local lymphatic and vascular architecture. These characteristics may alone or in combination with needle biopsy (which can be performed at the same time through the same device) provide better classification of lesions and enhance diagnostic yield.

BACKGROUND

Imaging with low dose film-screen mammography is the currently recommended method of choice for the early detection of nonpalpable breast cancer in women over age 40. The use of mammography has dramatically increased over the past ten years and approximately 35 to 40% of the eligible population undergoes mammographic screening. It is estimated that, barring a significant advance in cancer screening methods, the number of mammographic studies is likely to double over the next few years with a greater percentage of eligible patients being screened.

Despite the high sensitivity of mammography, up to 9% of palpable cancers show no corresponding imaging abnormality. Furthermore, with mammography, small cancers are often obscured by dense fibroglandular tissue. Another major limitation of mammography is its lack of specificity which has led to a marked nationwide increase in the number of surgical excisions for benign disease. It is estimated that 80 to 90% of surgical breast explorations and excisions are now performed for benign disease at a direct cost estimated at 3 to 4 billion dollars annually.

In addition, the apparent incidence of breast cancer has increased at a rate of approximately 3% per year since 1980 from 84.8 to 109.5 per 100,000, leading to an ever increasing number of surgical procedures for both benign and malignant conditions. Despite the apparent increasing incidence of breast cancer, the overall mortality for this disease remains constant. Whether this phenomenon represents the effects of earlier detection, better treatment methods, or changing diagnostic thresholds used for the earlier stages of breast cancer is unclear.

These changing patterns of clinical breast cancer have also led to modifications of the diagnostic approach to the suspicious but uncharacterized breast lesion, primarily with the development of image-guided needle biopsy methods. In parallel, more conservative and tissue-sparing therapies with reduced morbidity and mortality have been advocated and implemented to better adapt the aggressiveness of the therapeutic intervention to the stage of evolution and malignant potential of the cancerous lesion.

BODY

Specifically, we proposed that in vivo MR microscopy could help to better assess known imaging features as well as permit the evaluation of new features such as, for example, the mammary ducts from which cancer arises, the time-resolved pattern of contrast distribution, and the capillary density in or near lesions.

We concentrated on optimization of coil design to obtain high spatial and temporal resolution. Imaging studies were performed on a GE Signa 1.5T magnet with echo-speed upgrade. High resolution images were obtained with specially designed dual phased array surface coils with diameters ranging from 2-8 cm, following compression of the breast within two perspex plates. T1-weighted, T2-weighted and fat-suppressed post-gadolinium contrast T1-weighted images were obtained in each of 9 patients. Dynamic contrast uptake and distribution studies were also performed for all patients using a rapid imaging sequence (Spoiled Gradient Echo imaging) with a time resolution of 3 sec. All lesions were subsequently biopsied.

High-resolution images obtained from a patient with a biopsy-comfirmed fibroadenoma are shown in Figure 1. The lesion had a well-defined border for pre- (a) and fat-suppressed post-contrast (b) T1-weighted images. Figure 2a and b shows images from a biopsy-confirmed invasive ductal carcinoma, which demonstrates the lesion as spiculated, with non-uniform uptake of the contrast agent.

Figure 1a

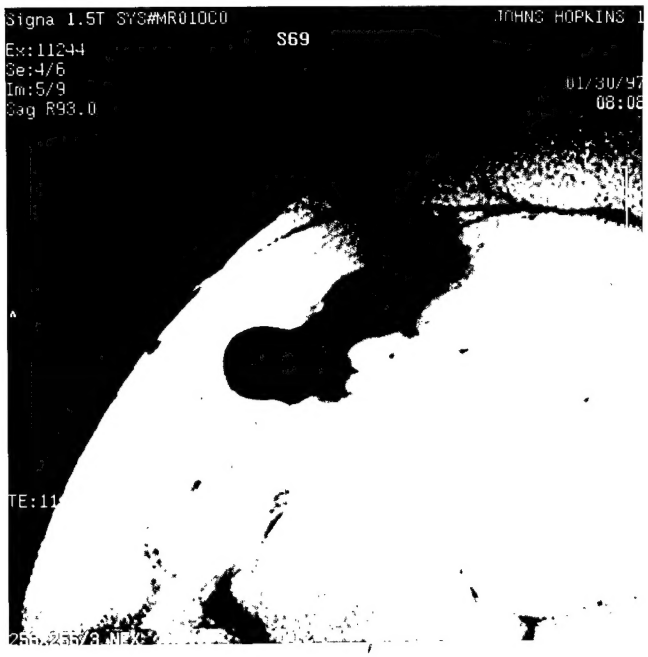

Figure 1b

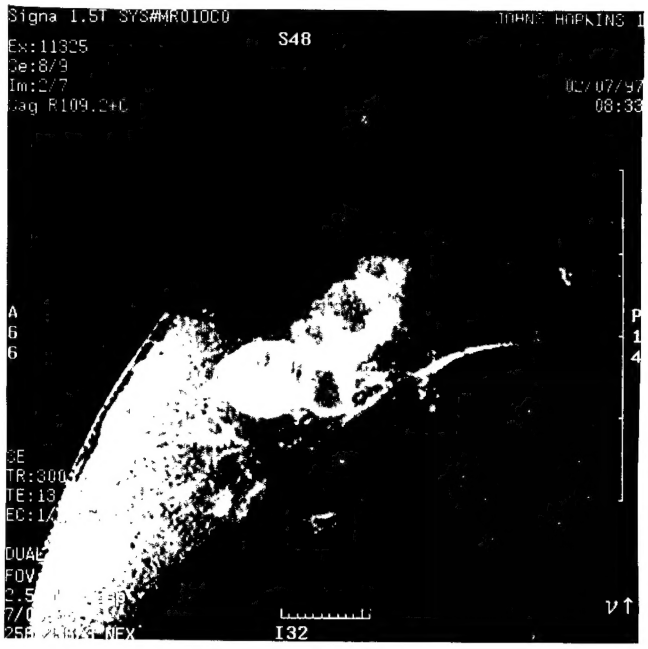

Figure 1 High resolution T1-weighted image obtained from a fibroadenoma. (a)Pre-contrast T1-weighted image acquisition parameters were: TR=300ms; TE=11ms; FOV=8cm x 8cm; 256x256 matrix; slice thickness = 2.5 mm, number of averages = 3. (b) Post contrast T1-weighted image acquisition parameters were as above except fat suppression was applied; TE=13ms.

Figure 2a

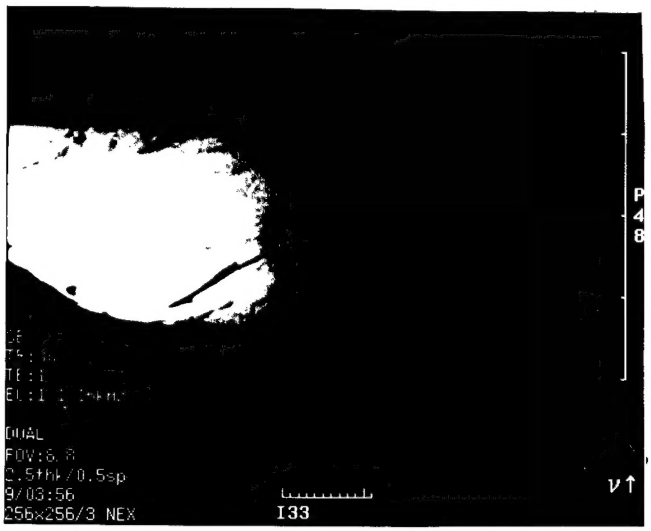

Figure 2b

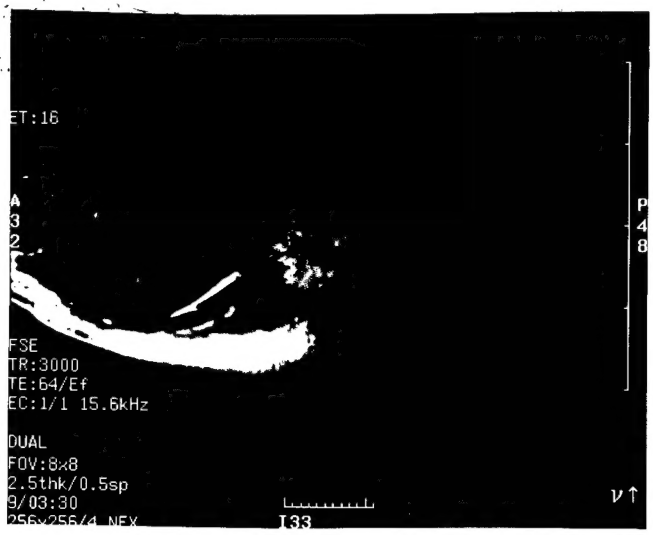

Figure 2 High resolution T1-weighted image obtained from an invasive ductal carcinoma. (a)Pre-contrast T1-weighted image acquisition parameters were: TR=300ms; TE=11ms; FOV=8cm x 8cm; 256x256 matrix; slice thickness = 2.5 mm, number of averages = 3. (b) T2-weighted image acquisition parameters were as above except TR=3,000 ms; TE=64ms.

Our tests on coil design showed that there was negligible coupling when the coil diameter was less than the distance of separation between the paired coils. The spatial resolution was dictated by the limitations of signal to noise ratio for in vivo imaging, even with specially designed phased array coils. Resolution was sufficient, however, to characterize the structure of the lesions. We found that the most significant difference between the two types of lesions was the appearance of the borders of each lesion. Benign lesions had smooth edges and malignant lesions had infiltrating edges.

The main problem with this method were the difficulties in positioning the coils in the proper location because of the relatively small size of the coils with respect to the breast.. In our current imaging protocol, we use a body RF coil for determination of the position of the lesion, and then we use large FOV coronal images of the breast to position the two coils. In some cases, this might require a few iterations. Once the coil is successfully positioned, we carry out our previously described imaging protocol in the sagittal imaging plane.

The second problem with this design is that when the lesions are closer to the chest wall, our compression plates do not allow proper positioning of the coil.

To solve these problems, currently we are developing a new design which consists of 12 small (3cm in diameter) coils. Since our GE 1.5 T Signa scanner is not capable of handling 12 channels, in our set-up, we manually select the desired coil pair that is closest to the target lesion. The unique advantage of this new design is that it simplifies the patient handling process and shortens the exam time. In addition, it allows imaging of lesions closer to the chest wall with high resolution.

CONCLUSIONS

We conclude that very high resolution MRI can help diagnose suspicious lesions and reduce the number of unnecessary biopsies.

We designed the system (Specific Aim 1), tested it on phantoms and on a small number of patients (Specific aim 2). We determined the problems (as described above), and began to redesign the coils while we continue to study more patients.

Capillary density was assessed using a dynamic contrast-enhanced imaging protocol in all patients. The number of patients is too small for a conclusion but our results to date have not conflicted with results currently being reported in the literature.

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